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How Small Farm Households Adapt to Risk

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An evaluation of crop insurance would be incomplete without an assessment of the alternatives available to farm households. Many cropping strategies and farming practices substitute for crop insurance by stabilizing crop revenue. Moreover, the stabilization of crop income does not necessarily imply stabilization of consumption, as many households have opportunities to earn other income. The availability and effectiveness of many of these risk-management alternatives are conditioned by public policy and determine the demand for crop insurance. The effects of public policy on risk management by farm households frequently go unnoticed. Policies that improve access to the land, labor, and credit markets might be more cost effective than crop insurance in strengthening risk management by farm households. So it is important to understand not only how well farm households manage risk without crop insurance but also how competing policies and crop insurance interact with traditional risk-management measures.

Two questions are crucial to an assessment of the efficiency of small-scale farmers' adjustment to risk: (1) do the present risk-management methods protect household consumption stability and preserve farm productive capacity, and (2) does reliance on these options result in sizeable losses in static or dynamic social efficiency? If the answers to these questions are yes and no, respectively, then the scope is limited for a public policy such as crop insurance both to improve farmers' risk adjustment and to contribute to social welfare.

To respond to these questions, we first describe farmers' risk management in three contrasting agroclimatic, socioeconomic, and institutional contexts in South Asia, Central America, and East Africa. Such comparative evidence is illustrative and not definitive; it only maps the boundaries of what farm households do to manage risk. Second, we review the evidence on how well traditional risk-management measures stabilize household income, singling out spatial diversification, intercropping, and

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tenancy. Last, we comment on the efficiency costs and the potential adverse effect on equity of traditional risk-adjustment practices. Conceptually, these costs represent potential benefits from a public-sector risk-management policy, such as crop insurance.

We focus on small farm households and yield risk. For farmers in such households, particularly if they are subsistence oriented, yield risk is a greater source of income variability than price risk. Also, crop insurance as a public policy is explicitly but not exclusively directed at reducing yield risk. Because of this orientation, our analysis applies more to rain-fed farming, where yield risk is dominant, than irrigated farming, where price risk is potentially the more important source of farm-income variability (Barah and Binswanger 1982).

Traditional Methods of Risk Management

Farmers in agriculturally risky environments have evolved several measures to deal with production risk. These measures have been observed with minor variations in several small farming systems in developing countries (Ruthenberg 1976, Collinson 1972, Norman 1974, Haswell 1973, and Navarro 1977).

Traditional methods of handling risk in small farm systems can be divided into (1) routine risk-preventing or risk-minimizing practices, usually adjustments to production and resource use before and during a production season; and (2) risk/loss-management mechanisms, which include farmers' later responses to lower-than-expected crop income caused by natural hazards, such as drought.

Loss Management

When crop income falls short of expectations, farm income can be preserved through the sale of producer durables (livestock and machinery), and through management of on-farm stocks and reserves.

Nonfarm income can also be a powerful force to compensate for lower-than-expected crop revenue. Access to sources of nonfarm incomes, occupational mobility, geographic mobility, and family remittances can help stabilize household income and consumption. Their effectiveness in offsetting farm income losses depends largely on the covariance between agricultural and nonfarm income within and across regions. In Southeast Asia many farm households derive a considerable share of total income from nonfarm sources (World Bank 1982). In Mexico and Central America some small farm households receive remittances from a network of relatives in the United States. Thus they are protected from the highly covariate nature of farm and nonfarm income, characteristic of small regions in developing countries. Such covariance greatly reduces the prospect of finding nonfarm employment in the same region that is afflicted with depressed crop income. Production risks across regions may be less highly correlated; hence temporary migration may be a more rewarding risk-adjustment strategy than occupational mobility within a region.

Potentially important loss-management responses are presented in table 2.1 for small farms in El Salvador, Tanzania, and India. In general, such mechanisms are not as important in Tanzania, where man/land ratios are lower than in India and El Salvador. Absence of a labor market and imperfections in other markets force farmers in Tanzania to rely more heavily on traditional crop-management strategies to cope with production risk.

Risk Management

Risk-management practices embodied in cropping strategies can be subdivided into those that relate primarily to diversification of resources and enterprises and those that relate to adjustments within cropping systems. Potentially important risk-management practices are also presented in table 2.1.[1]

Farmers exploit vertical, horizontal, and temporal dimensions of the natural resource base to reduce production risk. Planting on a toposequence is a mild form of vertical diversification, which allows flexibility in production conditional on the timing and quantity of rainfall at planting.[2]

Spatial scattering offers scope for improving crop income stability to the extent that production risks are not perfectly correlated across microenvironments. Likewise, staggered plantings and sequential diversification reduce variability to the extent that production risks are not perfectly covariate across time.

1. In looking at traditional risk-management strategies and practices, one can seldom distinguish between those where risk and expected profitability are in sharp conflict and those that are characterized by a lower variance in net returns and also higher average returns when compared to other alternatives. A good example of a risk-efficient practice is doubling maize; that is, breaking the stalk below the ear to facilitate field drying. Doubling and field drying are so much more profitable than competing alternatives in El Salvador that they are not included in our set of risk-management practices. If we had perfect information for a decision analysis on the production practices listed in table 2.1, and on alternative courses of action, we would not be surprised to find that for many environments and technology sets, what seem like risk-management strategies and practices are also the most profitable alternatives over time.

2. A more abrupt form is practiced by farmers in the mountain communities of the Andes (Guillet 1981).

TABLE 2.1 Risk/loss-management strategies, rain-fed small farms in northern El Salvador, the Kilosa area of Tanzania, and the semiarid tropics of India

Loss-management strategies	Risk-management strategies
El Salvador	
Informal mutual aid	Toposequential planting
Storage and recycling	Spatially scattered planting
Labor market participation and foraging	Temporally diverse planting
Public relief	Planting crop with insurance potential
Depletion and replenishment of assets[a]	Planting crop insensitive to temporal variability
	Mixed cropping and farming
	Planting many seeds per hill
	Splitting and skipping in input use
Tanzania	
Interlinked consumption and production	Toposequential planting
Public relief	Spatially scattered planting
Informal mutual aid[a]	Temporally diverse planting
Storage and recycling[a]	Planting crop with multiple uses
Depletion and replenishment of assets[a]	Planting crop with insurance potential
Labor market participation and foraging[a]	Planting crop insensitive to temporal variability
	Mixed cropping and farming
	Plant spacing (thinning and gap filling)
	Planting many seeds per hill
	Splitting and skipping in input use
India	
Interlinked consumption and production	Spatially scattered planting
Informal mutual aid	Planting crops with multiple uses
Storage and recycling	Planting crops with insurance potential
Linkages of agricultural factor markets	Planting crops insensitive to temporal variability
Depletion and replenishment of assets	Mixed cropping and farming
Labor market participation and foraging	Plant spacing (thinning and gap filling)
Public relief	Splitting and skipping in input use
	Toposequential planting[a]
	Temporally diverse planting[a]

[a] Action partially observed or empirical evidence lacking.

Crop-centered diversification is conditioned through the choice of crops with varying maturity periods, differential sensitivity to environmental fluctuations, and flexible end uses of the main products and byproducts. Such diversification is often manifested through intercropping by mixing seed and varying row arrangements.

Manipulation of plant populations in accordance with changing information on soil moisture, and input use dictated by emerging weather conditions also introduces flexibility into management.

India. The reliance on spatial diversification and crop diversification is illustrated in table 2.2 for the semiarid tropics of India. The Sholapur villages are located in a high-risk production environment, where cropping primarily takes place after the rainy season on residual moisture. In contrast, the Akola villages are located in a more assured production environment, where rainy-season cropping is practiced. The data suggest that both spatial and crop diversification are more widely employed in the more drought-prone villages near Sholapur.

Tanzania. The Kilosa area of Tanzania offers an excellent benchmark of the influence of production risk on cropping decisions. The region is characterized by short, uncertain rains from October to early December and long, more certain rains from late January to the end of April. The differences in cropping decisions clearly reflect greater insurance-oriented practices during the season of short rains (table 2.3). For example, more valley land is planted, and the incidence of intercropping, salvage crops, and cropping near the compound is greater. The share of staggered planting is lower because these rains recede sooner than the long rains.

El Salvador. In El Salvador, several studies document the use of risk-management practices by maize farmers. Hybrid maize is more likely to be planted in pure stands in valley land, while local maize varieties, which farmers perceive as more drought-tolerant, are intercropped with sorghum or field beans on hillsides (Cutie 1975, Walker 1981). In northeastern El Salvador, if the May maize planting fails, some farmers, in a rather desperate attempt to salvage something from the cropping year, plant a low-yielding maize crop later in the rainy season (Rodriguez, Alvarado, and

TABLE 2.2 Weather risk and diversification strategies in two semiarid areas of India

Item	Akola	Sholapur
Weather risk		
Annual average rainfall (millimeters)	820.00	690.00
Probability of favorable soil moisture in rainy season	.66	.33
Spatial diversification		
Scattered land fragments per farm	2.7	5.8
Split plots per farm	5.0	11.2
Fragments per farm by distance from village		
0 miles	0.2	0.0
0–0.5 mile	0.3	1.4
0.5–1.0 mile	1.1	3.4
Over 1 mile	0.1	1.0
Crop diversification		
Number of different sole crops observed in area	20	34
Number of different crop mixtures observed in area	43	56

Source: International Crops Research Institute for the Semi-Arid Tropics.

TABLE 2.3 Farming practices by season in four villages of Kilosa, Tanzania, 1980–81 (percent)

Farming practice	Oct–Dec.[a]	Jan–May[b]
	Share of year's planting	
Lowland planting	83	17
Upland planting	26	74
Planting in compound	92	8
	Share of season's planting	
Salvage crop planting[c]	72	32
Intercropping	95	79
Staggered planting	35	69

Source: Jodha (1982)
[a]Season of short, uncertain rains.
[b]Season of long, more certain rains.
[c]Salvage crops can be used before physiological maturity.

Amaya 1978). The renting of cropland for a fixed cash amount increased in El Salvador from 1961 to 1971. Part of this growth can be attributed to the buoyant demand for horizontal diversification (El Salvador 1974). Farmers have consistently rejected the advice to fertilize at planting and prefer to apply fertilizer eight days after planting, when they are assured that the crop has successfully emerged (Alvarado, Walker, and Amaya 1979).

Effectiveness of Risk Management

Evidence on the effectiveness of risk management by small farm households is scanty. Preliminary results over the five cropping years from 1975 to 1979 in three ICRISAT study villages in the semiarid tropics of peninsular India show that the coefficient of variation of net household income per person averaged 35 percent, and ranged from 15 to 85 percent (Walker and others 1983).[3] Crop income as a share of total income was positively and significantly associated with the coefficient of variation, which suggests that risk-management strategies were not sufficient to protect income.

Some summary evidence from drought areas in India broadly illustrates the size of fluctuations in farm income, the contribution of different adjustment mechanisms, and the multiple consequences of drought on household welfare (table 2.4). Shortfalls in crop and livestock income dur-

3. This estimate refers to nominal income. The results do not change appreciably when calculations are carried out on real income, as village foodgrain price indices showed little variability or trend over the five cropping years (Walker and others 1983).

TABLE 2.4 Changes in economic measures between normal and drought years for farms in various areas of India

Measure	Drought year change from normal year[a]	
	Smallest change	Largest change
Current commitments (percent change)		
Per-household consumption expenditure[b]	−8	−12
Per-household socioreligious expenditure[b]	−31	−64
Per-adult foodgrain consumption[b]	−12	−23
Household postponement of tax payment, etc.[c]	0	+27
Household withdrawal of children from school[c]	0	+42
Assets and liabilities (percent change)		
Asset depletion (sale, mortgage, etc.)[d]	−19	−60
Outstanding debt[e]	+64	+192
Income source (percent change)		
Crops[b]	−58	−82
Livestock[b]	−37	−73
Migration (percent households)		
Households with member outmigrating[b]	37	60
Animals outmigrating[b]	32	56
Migrating animals lost or dead[b]	28	53
Nonmigrating animals lost or dead[b]	59	87

Source: Jodha (1975, 1978) and original data sets of the studies.
[a] Postdrought year for current commitments and income source; predrought year for assets and liabilities.
[b] Three areas.
[c] One area.
[d] Five areas.
[e] Four areas.

ing the drought year were large by any standard. Despite risk-adapting cropping strategies and farming systems, the drought was so severe that crop and livestock income contributed only 5 to 16 percent to total sustenance income in the three areas studied. The shortfall in farm income was to some extent compensated by private borrowing and public relief, which contributed from 44 to 73 percent and 22 to 56 percent, respectively, to household income during the drought year.

In Latin America such detailed microeconomic inquiries (to our knowledge) are not available. What are available are recall surveys such as the one carried out in two villages in northern El Salvador on past and future mechanisms of adjustment to crop loss (table 2.5). Temporary migration to harvest export crops was a leading risk adjustment. This information furnishes some insight but does not allow quantification of the effectiveness of the risk adjustment.

TABLE 2.5 Risk-adjustment strategies of small-scale maize farmers in northern El Salvador (percent)

Strategy	Farmers using strategy as main adjustment to crop loss in 1977[a]	Farmers who might use strategy as main adjustment to crop loss in future years
Sale of livestock	20	36
Increased labor market participation[b]	26	62
Draw on family savings	5	2
Receipt of consumption loans in kind	10	0

Source: Walker (1980).
Note: Forty-two farmers in two villages.
[a]Does not add to 100, as 39 percent of farmers did not have to resort to any of these strategies.
[b]Seasonal migration to harvest cotton, coffee, and sugarcane.

Trends in Risk Management

The effectiveness of risk management by farmers is constantly changing in response to changes in resource and institutional environments.

Tanzania. In Tanzania the change has been for the worse. Public policy interventions have adversely affected traditional risk-handling methods. State marketing has siphoned off village food reserves. Regulations that compel farmers to plant a fixed acreage in cash crops have eroded production flexibility. The resettlement of villagers into compact communities at selected sites has deprived farmers of access to more diverse lands as well as to diversified farming systems, where tree crops were an important food source (Jodha 1982). Labor market restrictions prohibiting the hiring of agricultural labor and block farming have also reduced farmers' freedom.

India. In India many well-intentioned public policies have generated side effects that have made risk management by small-scale farmers less effective in drought-prone areas. Intrayear reserves and intrayear security stocks of food grains and fodder have ceased to be important components in risk adjustment (Jodha 1981b). Group measures such as mutual risk-sharing arrangements, seasonal migration, and informal interlocking of agricultural factor markets are less compatible with new village institutions. Legal provisions regulating credit, labor contracts, mortgage of assets, and tenancy are often insensitive to the specific adjustment problems of drought-prone areas (Jodha 1981b). For these and other reasons, formal public relief has assumed greater significance in drought-prone areas. The enormous public investment in irrigation during the last decade has probably diminished risk for the country as a whole and has at least partially compensated for the deterioration of traditional risk-management measures.

El Salvador. In El Salvador the picture is less clear. On the positive side, such technological innovations as hybrid maize and small silos for storage have been accepted by many small-scale farmers. On the negative side, increasing population pressure on land, an inactive land market, and the demise of the traditional *colono* form of tenancy, which though exploitative was risk adjusting, have eroded the effectiveness and availability of traditional risk-management methods.

Three Risk-Management Measures

Village-level studies by ICRISAT provide some evidence on the efficiency of three risk-management actions that have received considerable attention in the literature.

Spatial diversification. Spatial diversification of farm plots is a closer substitute for crop insurance than other informal means of risk adjustment. Access to heterogeneous agroclimates, across which production risks are not perfectly correlated, endows farmers with greater flexibility to cope with yield risk.

The incidence of heterogeneity or location specificity may be more common than is generally thought. For example, for the last seven years, monthly July rainfall measured in two gauges located at opposite ends of the 1,400-hectare main experimental station at ICRISAT is correlated at .61, which is far less than what one would expect for such a short distance on flat land.

Even within a village, there may be considerable heterogeneity in yield outcomes. Figure 2.1 shows the correlations between individual farm yields and the average village yield for selected crops. For most crops, yields are positively correlated, but there are a surprising number of cases where the correlations are either low or not statistically significant. This is particularly true for local cotton in the Akola village where from 1975 to 1980 40 percent of the farmers' yields varied inversely with the average village yield. Spatial diversification appears to have been effective in stabilizing local cotton yields in Akola. It is likely, too, that a homogeneous-area approach to compulsory crop insurance would increase instability in crop revenue for many cotton producers in the village.

Still, spatial diversification does not appear to be as strongly associated with net crop income stability as does crop diversification (Walker, Singh, and Jodha 1983). In two regions, crop diversification is negatively and significantly correlated with the coefficient of variation of net crop in-

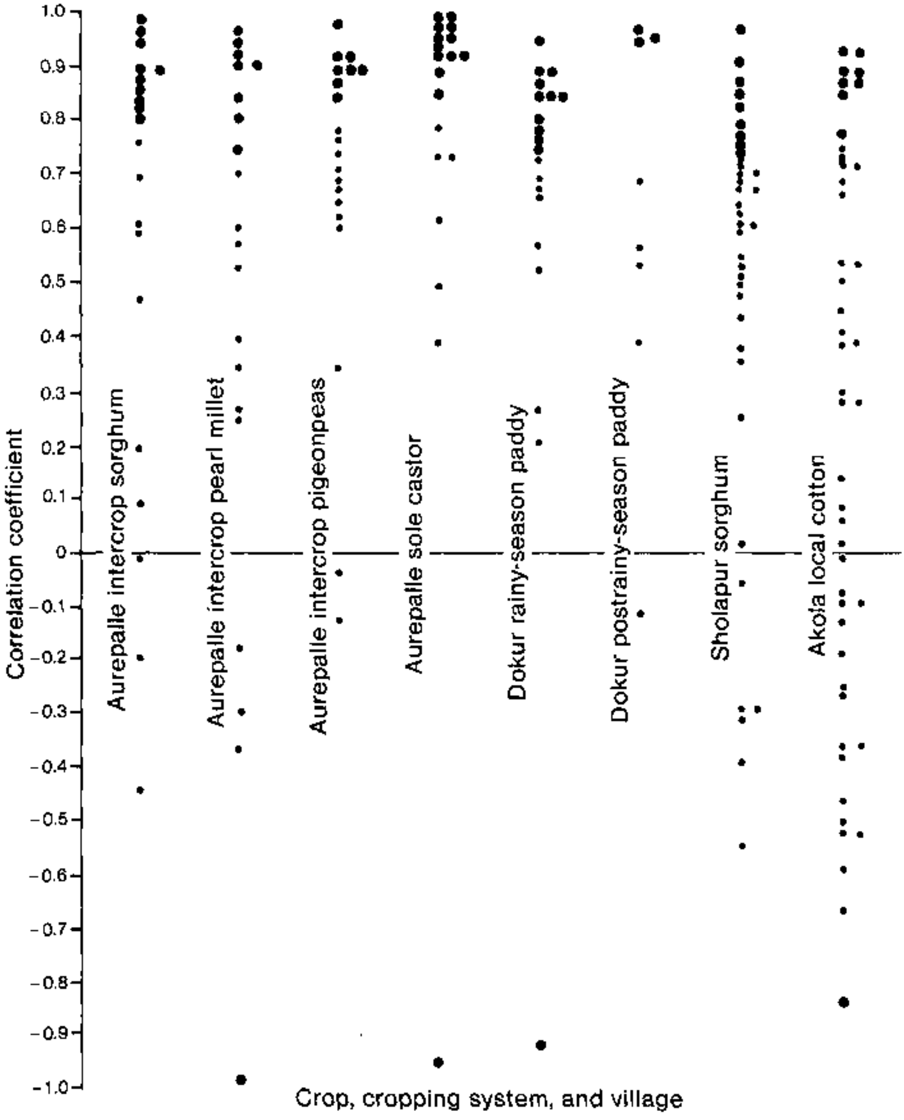

FIGURE 2.1 Correlations between individual-farm yields and average village yield, 1975 to 1979 or 1980

Note: ● Statistically significant at the 5 percent level. • Statistically insignificant.

come, while greater spatial diversification is not significantly correlated with the coefficient of variation of net crop income. In the remaining region, greater spatial diversification is inversely associated with the coefficient of variation of net crop income.

Tenancy. There are many reasons for tenancy (Newbery 1975, Binswanger and Rosenzweig 1984) and an almost unlimited number of ways to specify a contract. Risk sharing is often cited as an important reason, but what is frequently overlooked is that tenancy affords a means to manage losses incurred in previous cropping years. This is particularly true in areas where the incidence of drought accentuates the importance and extent of tenancy.

The potential for loss management in tenancy contracts is illustrated with data from two ICRISAT studies of villages located in the drought-prone district of Sholapur in India. A severe drought in 1972–73 led to the death or sale of many bullocks, which reduced the capacity of many farm households to reinitiate cultivation in the postdrought year. About 24 percent of all farm households in the two villages had to lease out all their land (Jodha, Asokan, and Ryan, 1977). Tenancy transactions tended to equalize land/bullock ratios. Before the transactions, land area per owned bullock in the two villages was 18.3 and 30.9 hectares for landowners, and 3.4 and 7.2 hectares for tenants. Following tenancy, land area per owned bullock declined to 5.5 and 5.8 hectares for landowners and increased to 7.2 and 8.2 hectares for tenants (Jodha 1981a). Recent evidence also suggests that sharecropping in the Sholapur villages is more common on inferior land that is more susceptible to crop failure (Singh and Walker 1982).

The terms of the tenancy contracts were flexible enough to satisfy the needs of both parties. Table 2.6 presents the risk implications of tenancy according to tenancy arrangements. The arrangements are defined from the perspective of landowners, many of whom lost productive capacity because of drought. Both the payment of a fixed rental independent of the size of the harvest and net output sharing imply risk transfer to tenants. When input and output are shared by both parties, risk is shared. Tenancy arrangements that help manage risk losses are conditioned by the lagged impact of drought-induced losses. They include (1) sharing of all inputs except bullocks (which were lost during the past drought); (2) crop input/output sharing arrangements subject to advance loans to landowners, adjustable against their shares to meet their preharvest resource constraints; (3) land-lease arrangements linked to labor and credit; and (4) other factor and product market contracts between landowners and tenants.

Tenancy arrangements involving the transfer of risk comprised about 29 percent of the tenancy observations. About 57 percent had explicit risk-sharing connotations, and over 60 percent had risk/loss-management implications.

TABLE 2.6 Risk implications to landlord of eleven tenancy arrangements, Sholapur area, India, 1975–78

Tenancy arrangement (number of farms)	Risk implication
Rent essentially fixed but subject to harvest (1)	Implicit risk sharing
Rent fixed, independent of harvest (2)	Risk transfer to tenant
Advance loan, rent subject to harvest (2)	Implicit risk sharing; risk/loss management
Input and output sharing (14)	Explicit risk sharing
Input (excluding bullock) and output sharing (28)	Explicit risk sharing; risk/loss management
Input and output sharing with adjustable advance loan (30)	Explicit risk sharing; risk/loss management
Net output sharing (19)	Risk transfer to tenant
Net output sharing with adjustable advance loan (17)	Risk transfer to tenant; risk/loss management
Risky plot tenancy with no fixed rental, no advance loan, meager crop share (19)	Implicit risk sharing
Midseason leasing with share in output (9)	Risk transfer to tenant
Land lease linked to labor and credit contracts (22)	Explicit risk sharing; risk/loss management

Source: Jodha (1981a).

In Sholapur, tenancy clearly helped equalize factor endowments and enabled the sharing of production risk. In Asia, most comparative empirical studies suggest that, once other variables are accounted for, the efficiency cost (in terms of low input intensity or nonadoption) from tenancy is negligible (Binswanger and Rosenzweig 1984). In Latin America, fewer empirical studies are available, but they also point to this conclusion (Colmenares 1975, Cutie 1975, Walker 1980).

Intercropping. Perhaps no single feature of small farm agriculture is as striking as the high incidence of intercropping, or mixed cropping (Jodha 1981c, Norman 1974). Intercropping is often praised as a risk-reducing practice in the agronomic and economic literature (Papendick, Sanchez, and Triplett 1976, Bliss 1979). Risk reduction due to diversification has to be separated from the risk-reducing attributes of intercropping by itself, which must be compared to pure stands. This is the perspective most agronomists adopt when they compute land-equivalent ratios of yield in sole-stand and intercropped treatments.[4]

4. Aside from risk reduction, intercropping may be superior to sole cropping in other dimensions (Jodha 1981c, Norman 1974).

Intercropping allows greater yield stability for three reasons (Willey 1981): (1) higher yield in stress conditions, (2) lower incidence of disease and pests, and (3) compensatory yields.

Higher yield under stress has been documented in experimental field trials, where under conditions of moisture stress, intercropping showed a yield advantage over sole cropping (ICRISAT 1980, p. 209). These results probably depended on differences in plant population between intercropping and pure stands.

The second potential source of risk reduction is extremely specific to the host, pest, and parasite (Bhatnagar and Davies 1981). For instance, in pigeonpea crops in India, wilt is reduced when the pigeonpeas are intercropped with sorghum (Willey, Rao, and Natarajan 1980). However, pigeonpeas intercropped with sorghum are subject to pod borer (Bhatnagar and Davies 1981), and there is fragmentary evidence that sterility mosaic is also a greater hazard.

Yield compensation arises from the spatial and chronological responses of species or varieties to the incidence and timing of biological and agroclimatic risk. These risks have a differential effect on crop productivity. Risk reduction in intercropping originates from the ability of at least one crop in the system to compensate for the failure or low yield of another crop. For example, cereals such as millet can partially compensate for low plant stands of other cereals through greater tillering. Compensation is conditioned by a crop's ability to take advantage of sunlight, soil nutrients, or soil moisture "released" by crops that are adversely affected. Compensation would not be possible in pure stands, because all plants would be affected in the same way.[5]

If yield compensation was common, the yield covariance between species planted in a mixed or intercropped system would be less than for proportional areas of the same crops planted in pure stands. In cases of high compensation in high-risk environments, we would expect to see negatively covariate yields. Unfortunately, not enough multiyear and multilocational data are available to compare intercropping and pure stands.[6] A less than ideal but still promising alternative is to evaluate the risk performance of common intercropping systems in farmers' fields. We hypothesize that where compensation is greater, yields between crops are less posi-

5. This is an overstatement for some sources of risk such as insect and disease damage, which may differentially affect plants in pure stands and thus widen the scope for compensation.

6. In one of the few attempts to assemble and analyze such data, Rao and Willey (1980) evaluated yield stability in a sorghum/pigeonpea intercrop. Based on bounded rationality and variance criteria, they found that intercropping provided greater yield stability than sole cropping. However, the nature of their data does not permit the separation of pure time and location effects. That is, yield stability and adaptability are confounded.

tively covariate. We would therefore assign low risk-reducing potential for cropping systems where intercrop yields are significantly and positively correlated over time.

An assessment based on ICRISAT's data provides some estimate of the size of expected compensation effects. Two intercropping systems, one traditional and one somewhat improved, were analyzed. Plot data were available for thirty farming households in each of two villages (Aurepalle and Kanzara) for the six cropping years from 1975 through 1980. The intercropping systems were the most common ones encountered in each village.

The traditional cropping system in Aurepalle consists of row intercropping two medium-duration cereals (local pearl millet and sorghum) with a long-duration grain legume (pigeonpeas). The three crops are grown in a high-risk, low-fertility environment. Sources of risk and crops with a potential for yield compensation are described in table 2.7. We would expect a strong compensatory-yield effect between pearl millet and sorghum only when shootfly inflicts damage on sorghum.[7] There is more scope for compensation between pigeonpeas and the two cereals. A clear implication of table 2.7 is that the later a crop is afflicted, the less chance there is for compensation by another crop.

In order to test the hypotheses suggested by table 2.7, we calculated the yield correlation coefficients for the three crops for the 169 plots in the sample.[8] If compensation effects were strong over many years, we would expect a negative correlation between yields of the two crops. That is, low yields from one crop would be compensated by high yields from the other crop because of reduced competition. Lower correlation coefficients would imply greater risk-buffering capacity. The size of such correlations based on yield data purged of management effects depends on the multivariate distributions of yield risk and their crop-specific interactions. For this particular cropping system, we would expect a positive correlation between sorghum and millet yield and a zero or slightly negative correlation between the yield of either cereal and pigeonpea.

As expected, sorghum and pearl millet yields were significantly and positively correlated at .63 and insignificantly associated with pigeonpea

7. If the initial monsoon rains are late, the incidence of shootfly increases, and farmers respond by planting more castor in fields originally destined for the cereal/pigeonpea mixture. Farmers therefore do not have to rely solely on yield compensation from intercropping.

8. The yield data are adjusted for management effects by regressing yield on farmer and season binary variables using least squares, dummy variable regressions (Maddala 1977). For four farmers, sorghum yields are "corrected" for linear management effects; for pearl millet and pigeonpea there is little evidence of significant differences in technical efficiency among farmers. This is what one would expect with a low-input traditional cropping system. It is important to note that yield variability from plot-specific sources has not been explicitly controlled for in the data.

TABLE 2.7 Sources of risk to traditional sorghum/pearl millet/pigeonpea intercrop systems, and yield compensation relations between crops, Aurepalle village, India

Source of risk	Affected crop	Effect	Compensatory crop
Shootfly	Sorghum	Poor stand establishment	Pearl millet, pigeonpea[a]
Early drought	Sorghum, millet	Poor stand establishment	Pigeonpea[a]
Midseason drought	Sorghum, millet	Reduced yield	Pigeonpea[b]
Excess late-season rain	Sorghum	Earhead bugs, grain mold	None
Late-season drought	Pigeonpea	Reduced yield	None
Pod borer	Pigeonpea	Damaged pods	None

[a]Strong compensation.
[b]Weak compensation.

yields at .06 and .11, respectively. The evidence indirectly suggests that for this cropping system, intercropping provided little risk protection. The same finding applied to the second cropping system, featuring three long-duration crops of local cotton, local sorghum, and pigeonpea cultivated in Kanzara village, which has more assured rainfall. Adjusted yield data for 190 plots show significant correlations (.42, .25, and .15) at the 5-percent level between yields of cotton and sorghum, cotton and pigeonpeas, and sorghum and pigeonpeas. One would expect such a result for crops that mature at about the same time.

Efficiency Costs and Adverse-Equity Impacts of Risk Management

The risk-management actions of small farm households can entail efficiency costs and adverse-equity impacts. If these households had access to an additional risk-management measure, such as public crop insurance, perhaps the costs could be lowered and the inequities lessened. Any new policy aimed at enhancing risk management by small farm households should augment or make more effective their choices in managing risk. An analogy can be drawn to public price stabilization policies, which can displace traders and speculators and reduce price stability and thus cause little or no stabilization in prices (Peck 1977).

One important consequence of crop insurance could be shifts to cropping patterns that lead to higher average incomes. This issue is addressed at length in chapter 3 and will not be taken up here. Other benefits might be the adoption of technology, and greater use of modern inputs, less depletion of assets during bad years, less shifting of risk adjustment to landless labor, and a decline in land fragmentation.

Low Input Use and Nonadoption of New Technologies

Perhaps no risk-management theme has received as much empirical attention as the adverse effect of risk aversion on investment in new agricultural technologies and use of modern inputs. Yet the evidence from positive analyses shows that the potential for intensified farming does not increase by correcting for risk aversion.

Participants in a risk-reducing crop insurance program could capture innovators' rents as early adopters, but they would also be exposed to innovators' losses from unprofitable new technologies (Binswanger and Ryan 1977). A perceived reduction in risk could speed up the adoption cycle. However, unless acceptance by a few precludes adoption by the majority, welfare is determined by ultimate adoption, rather than by early adoption (Gerhart 1975).

Therefore, the more relevant welfare question asks the reasons for nonadoption of mature innovations. Intuitively, the output cost of risk aversion is greater for recommended inputs that are indivisible or are characterized by large financial risk. Recommended inputs are frequently clustered into packages that imply all-or-nothing courses of action. In reality, farmers make adoption decisions on each component of the cluster in a piecemeal, stepwise fashion (Mann 1977). The package approach to the diffusion process greatly accentuates risk and, therefore, the potential for risk aversion as an impediment to adoption. A perhaps biased sampling of positive risk-related research on the adoption of mature innovations in Latin America indicates: (1) that when packages are partitioned into their components, risk aversion is reduced (Gladwin 1977); (2) that the conflict between expected profitability and risk is not as sharp as anticipated (O'Mara 1971); and (3) where risk aversion is the primary reason for nonadoption, moving to a risk-neutral position yields only a marginal increase in expected income (Walker 1981).[9]

It is difficult to forge a consensus; witness adoption research on the Puebla project, where five investigators (Benito 1976, Diaz 1974, Gladwin 1977, Moscardi 1976, and Villa Issa 1976) arrived at quite dissimilar conclusions and policy implications. However, the overriding importance given to on-farm profitability by Perrin and Winkelmann (1976) in their summary of the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) adoption studies in the 1970s rings as true today as it did to Griliches in 1957.

9. Similar results are reported by Ryan (1972), who assessed the effect of risk aversion on optimal use of fertilizer for potatoes in Peru. He found that the marginal cost (supply) curve for potatoes was only marginally affected when one allowed for risk aversion.

Asset Depletion

Reliance on liquidation of productive assets to even out fluctuations in farm income may have strong implications for economic growth and equity in risk-prone areas. Jodha (1975) has argued that farmers' risk adjustment is conditioned by repeated weather cycles, which translate into asset depletion and replenishment cycles. If governments base risk-management decisions on changes in consumption levels, asset depletion may have already run its course and farm productive capacity may have eroded, perhaps permanently.

In the longer run, such cycles signify stagnating investment in risk-prone regions. Restoring farm productive capacity is a slow, accretionary process, because farmers face a buyers' market in the disaster year and a seller's market in the postdisaster year (Jodha 1975). Asset depletion and replenishment cycles are probably not nearly as severe in most of Latin America as they are in West Africa, East Africa, and South Asia. Nonetheless, their growth and equity implications should not be ignored in the assessment of public policies whose intent is to reduce farmers' risk.[10]

Shifting Risk Adjustment to Landless Labor

Increased participation in the casual-labor market is an important adjustment mechanism for small-scale farmers, particularly in Central America, where basic grains are grown from May through November and export crops such as coffee, sugarcane, and cotton are harvested from December through March. With increased seasonal migration by small-scale farmers, risk adjustment is partially shifted to landless agricultural laborers, who are least able to cope with risk. In any year, the demand for harvesting labor is highly inelastic and is determined by the size of the crop. Increased labor supply translates into decreased real wages or into higher unemployment. Effective crop insurance could therefore indirectly contribute to the income stability of landless laborers. (Of course, a well-timed and flexible public-works program would directly reduce the cost of risk adjustment borne by landless agricultural laborers.)

Land Fragmentation

Efficient crop insurance could also slow land fragmentation of small farms in Latin America. Fields are subdivided and left to heirs in what we suspect

10. Browning (1971) and Durham (1979) contend that low coffee yields and prices forced many small-scale landholders in El Salvador to sell to large haciendas in the 1930s and therefore directly stimulated increasing land concentration.

is an attempt to maintain diverse holdings.[11] Casual empiricism suggests that this is also the case for parts of the semiarid tropics of India. Crop insurance could lessen the use of spatial diversification as a risk-management strategy and create a more favorable environment for consolidation of land holdings in countries where man/land ratios are high. Once again, we need more empirical evidence (in this case on the determinants of the intergenerational transfer of wealth and on the social costs of land fragmentation) before benefits can be quantified.

Conclusions

It is easier to describe how small farm households adapt to risk than to pass judgement on whether such adaptations are effective. Fluctuations of net household income of about 35 percent over five cropping years, and household food grain consumption shortfalls ranging from 12 to 23 percent during a drought, suggest that risk management is far from perfect for these households.

We found convincing evidence, based on village-level data in rural southern India, that tenancy was actively used to spread production risk within and across cropping years. Crop and spatial diversification even within an area as small as a village may enhance yield stability in some ecological settings. Contrary to expectations, intercropping by itself contributed little to yield stability.

The effectiveness of risk management by small farm households is largely an empirical issue. Household economics that features intertemporal decision making can furnish some insight. However, the most important constraint to understanding farmers' risk adjustment is the paucity of panel data over many years for relatively large samples. For crop insurance, knowledge about the influence of crop revenue on consumption stability is sorely needed. While we may not know as much as we would want, we are sure that when tenancy is banned, mechanization is subsidized, and capital is underpriced in the formal market, risk management by small farm households suffers, and the burden of adjustment falls more heavily on landless laborers. We are less sure that a public program of crop insurance is the cure, or even a step in the right direction.

11. As Roumasset (1976) has pointed out, alternative explanations may underlie what looks like risk-averse behavior. Presumably, if there were enough plots, an owner could take into account land quality and give each heir equitable shares without fragmenting fields.